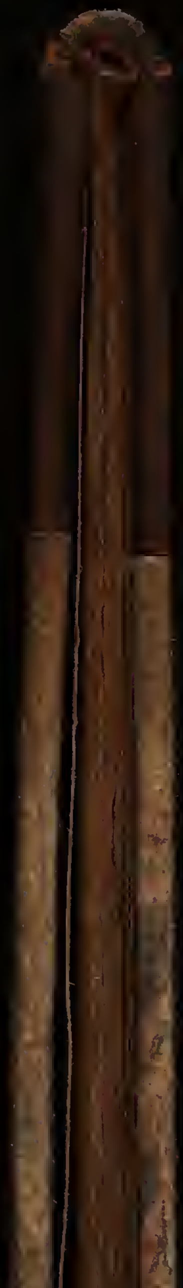
1658

LYON — APPENDIX OF DIALLING



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[COLLINS, J.]

Part of Collins. The election of a
parliament 1858

88326

AN APPENDIX

Touching

REFLECTIVE DIALLING.

By JOHN LYON:

Profeſſor of this, or any other part of the Mathematicks, *neer* Sommerſet *Houſe in the* Strand.

LONDON,
Printed *Anno Domini,* 1658.

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DIRECT DIALLING

By a Hole or Nodus.

To draw a Dial under any window that the Sun ſhines upon by help of a thread faſtened in any point of the direct Axis found in the Ceiling, and a hole in any pane of glaſſe, or a knob or Nodus upon any ſide of the window or window-poſt.

CONSTRUCTIO.

FIrſt, draw on paſtboard or other material, an Horizontal Dial for the Latitude propoſed.

Then by help of the Suns Azimuth, which may be found by help of a general Quadrant, at any time, or by knowing the true hour of the day with the help of the ſaid Horizontal Dial: and draw that true Meridian from the hole or Nodus propoſed, both above on the Cieling, and below on the walls and floor of the Room; ſo that if a right line were extended from the ſaid hole or Nodus by any point in any of thoſe lines, it would be in the meridian Circle of the World.

To finde a point in the direct Axis of the world, which will ever fall to be in the ſaid Meridian, in which point the end of a thread is to be faſtened.

FIrſt, fix the end of a thread or ſmall ſilk in the center of the Hole or Nodus, and move the other end thereof up or down in the ſaid meridian formerly drawn on the Cieling or wall, untill by applying the ſide of a Quadrant to that thread, it is found to be elevated equal to the Latitude of the place ; ſo is that thread directly ſcituated parallel to the Axis of the world, and the point where the end of that thread toucheth the meridian either on the Cieling or wall, is that point in the direct Axis ſought for, wherein fix one end of a thread, (which thread will be of preſent uſe in projecting of hour-points in any place propoſed, then :

To find the Hour-points either under the window, or any other convenient place in the Room.

Place the center of the ſaid Horizontal Dial in the Center of the Hole or Nodus ; alſo ſcituate the ſaid Dial exactly parallel to the Horizon, and the meridian of the ſaid Dial in the meridian of the world, which (as before) may eaſily be done, if at that inſtant you know the true hour of the day.) Then take the thread whoſe end is fixed in a point in the direct Axis, and move it to and fro, until the ſaid thread doth interpoſe between your eye, and the hour-line on the ſaid Horizontal Dial which you intend to draw, and then keeping your eye at that ſcituation, make a point or mark in any place where you pleaſe, or under the window, ſo that the ſaid thread or ſtring may interpoſe between that point or mark ſo made, and your eye, as aforeſaid ; which ſaid point ſo found will ſhew the true time of the day at that hour all the year long, the Sun ſhining thereon, ſo will that point, together with the ſaid thread, ſerve to ſhew the hour, inſtead of an hour-line.

In like manner, the ſaid thread fixed in the Axis may be again moved to and fro, until the ſaid thread doth interpoſe between the eye and any other hour-line deſired on the ſaid Horizontal Dial and then (as before) make another point or mark in any place at pleaſure, or under the ſaid window, by projecting a point from the eye, ſo that the ſaid thread alſo interpoſe between that point to be made and the eye, ſo will that point ſo found ſhew the true time of the day for the ſame hour that did the hour line on the ſaid Horizontal Dial, which was ſhadowed by the ſaid thread.

In like manner may be proceeded (by help of that thread, and the ſeveral hour-lines on the ſaid Horizontal Dial) to finde the other hour-points which muſt have the ſame numbers ſet to them as have the hour-lines on the ſaid Horizontal Dial.

Otherwiſe to make a Dial from a hole in any pane of glaſſe in a window, and to graduate the hour-lines below on the Sell, or Beam, or on the ground, that hole is ſuppoſed to be the center of the Horizontal Dial, and being true placed, the ſtile thereof, if ſuppoſed continued, will run into the point in the Meridian of the Cieling before found, where a thread is to be fixed; then let one extend a thread faſtned in the center of the Horizontal Dial parallelly to the Horizon, over each reſpective hour-line, and holding it ſteady, let another extend the thread faſtened in the Meridian, in the Cieling along by the edges of the former Horizontal thread, and ſo this latter thread will finde divers points on the ground, through which if hour-lines be drawn, and the Sun ſhine through the hole in the pane of Glaſſe before made, the ſpot of the Sun on the ground ſhall ſhew the time of the day.

For the points that will be thus found on the Beam or Tranſome, the thread fixed in the Cieling, or inſtead of it a piece of tape there fixed muſt be moved ſo up and down, that the ſpot of the Sun may ſhine upon it, and being extended to the Tranſome or Beam graduated with the hour-lines, as before directed, it there ſhews the time of the day. Here note, that it will be convenient to have that pane of Glaſſe darkened through which that ſpot is to ſhine.

In like manner may a Dial be made from a nail head, a knot in a ſtring tied any where a croſſe, or from any point driven into the bar of a window, and the hour-lines graduated upon the Tranſome or board underneath.

To make a Reflected Dial on the Ceiling of the Room is onely the contrary of this, by ſuppoſing the Horizontal Diall with its ſtile to be turned downwards, and run into the true meridian on the ground, where the thread is to be fixed, and to be extended along by the former Horizontal thread (held over the reſpective hours as before) upward, to find divers points in the Cieling, as ſhall afterwards be ſhewed.

Of Dials to ſtand in the Weather.

These may be alſo made by help of an Horizontal Dial.

DRive two nails or pins into the wall, on which the edge of a Board of competent breadth may reſt, then to hold up the other ſide of the Board, drive two hooks into the wall above, whereto with cord or line the outſide of the Board may be ſuſtained, and this Board being Horizontal, place the Horizontal Dial its Meridian-line in the true Meridian of the world. If a Plain look towards the South, the ſtile of the Horizontal Dial continued by a thread from the center will run into the Plain, which note to be the center of the new Dial, as alſo that line is the new ſtile, which muſt be ſupported with ſtayes, when you fix it up.

By a thread from the center laid over every hour-line on the Horizontal Dial, croſs the Horizontal line of the Plain, which note with the ſame hours the Horizontal Dial hath.

The hour-lines on the Plain are to be drawn from the center before found through thoſe points, and ſo cut off by the Dial, or continued at pleaſure.

If the Center of the Dial be aſſigned before you begin the work, in ſuch Caſes you may remove the Horizontal Dial up and down, keeping it ſtill to the true poſition or hour, till you finde the Axis or ſtile run into the Center.

But if the Plain look into the Eaſt or Weſt, then poſſibly the Axis of the Horizontal Dial will not meet with the Plain: in ſuch Caſes you muſt fix a board ſo, that it may receive the Axis, (the board being perpendicular to the Plain) this ſtile or Axis is to be faſtened to the Plain by two Reſts, the hour-lines may be drawn by the eye, or ſhadowed out by a Light: Bring the thread that repreſents the Axis or ſtile into any hour-point (on the Horizontal Dial) by your eye or ſhadow; at the ſame time the thread or ſhadow making marks on the Plain, ſhews where the hour-lines are to paſſe.

After the ſame manner any hour-line is to be drawn over any irregular or crooked Plain. Further obſerve, that any point in the middle, or neer the end of the ſtile will as well ſhew the hour of the Day, as the whole ſtile.

Of Refracted Dials.

IF you ſtick up a pin or ſtick, or aſſign any point in any concave Boul or Diſh, to ſhew the hour, and make that the center of the Horizontal Dial, aſſigning the meridian-line on the edges of the Boul, point out the reſt of the hour-lines alſo on the edges of the Boul, and taking away the Horizontal Dial, elevate a ſtring or thread from the end of the ſaid pin faſtned thereto over the Meridian-line equal to the Elevation of the Pole or the Latitude of the place; then with a candle, or if you bring the thread to ſhade upon any hour-point formerly marked out on the edges of the Boul, at the ſame time the ſhade in the Boul is the hour line.

And if the Boul be full of water, or any other liquor, you may draw the hour-lines, which will never ſhew the true hour, unleſſe filled with the ſaid Liquor again.

Reflected Dialling.

To draw a Reflected Dial on any Plain or Plains, be they never ſo Gibous, and Concave, or Convex, or any irregularity whatſoever, the Glaſs being fixed at any Reclination at pleaſure, (provided it may caſt its Reflex upon the places propoſed.) Together with all other neceſſary lines or furniture thereon, viz. *the Parallels of Declination, the Azimuth lines, the Parallels of Altitude (or proportions of ſhadows) the Planetary Hour-lines, and the* Cuſpis *of thoſe Houſes which are above the Horizon, &c.*

1. *If the Glaſſe be placed Horizontal upon the Tranſome of a window, or other convenient place:*

How upon the Wall or Cieling whereon that Glaſſe doth reflect to draw the Hour-lines thereon, although it be never ſo irregular, or in any form whatſoever.

CONSTRUCTIO.

First, draw on Paſtboard or other Material an Horizontal Dial for the Latitude propoſed.

Then by help of the Azimuth, or at the time when the Sun is in the Meridian; or by knowing the true hour of Day, whereby may be drawn ſeveral lines on the Cieling, Floor, and Walls of the Room: ſo as in reſpect of the center of the Glaſſe they may be in the true Meridian-circle of the World: For if right lines were extended from the center of the ſaid Glaſſe by any point, though elevated in any of thoſe lines ſo drawn, it would be directly in the Meridian Circle of the World.

Now all Reflective Dialling is performed from that principle in *Opticks*, which is, *That the angle of Incidence is equal to the angle of Reflection.* And as any direct Dial may be made by help of a point found in the direct Axis, ſo may any Reflected Dial be alſo made by help of any point found in the Reflected Axis.

And in regard the reflected Axis for the moſt part will fall above the Horizon of the Glaſſe without the window, ſo that no point there can be fixed, therefore a point muſt be found in the ſaid Reflected Axis continued below the Horizontal of the ſaid Glaſſe, until it touch the ground or floor of the Room in ſome part of the Meridian formerly drawn, which point will be the point in the reverſed Axis deſired, and may be found, as followeth.

One end of the thread, being fixed at or in the center of the ſaid Glaſſe, move the other end thereof in the meridian formerly drawn below the ſaid Glaſſe, until the ſaid reverſed Axis be depreſſed below the Horizon, as the direct Axis was elevated above the Horizon, which may be done by applying the ſide or edge of a *Quadrant* to the ſaid thread, and moving the end thereof to and fro in the ſaid meridian, until the thread with a plummet cut the ſame degree as the Pole is above the Horizontal Glaſſe, and then that point where the end of the thread toucheth the Meridian either on the floor or wall of the room, is the point in the reflected reverſed Axis ſought for.

Now if the Reverſed Axis cannot be drawn from the Glaſſe by reaſon of the jetting of the window or other impediment, that point in the reverſe Axis may be found by a line parallel thereto, by fixing one end of it on the Glaſſe, and the other end in the meridian, ſo as that it may be parallel to the floor or wall in which the reverſed Axis-point will fall, and finde the Axis point from that other end of the lath: ſo if the ſame Diſtance be ſet from that point backward in the Meridian on the floor, as is the Lath, the point will be found in the Reverſed Axis deſired.

Thus having found a point in the reflected reverſed Axis; it is not hard, by help whereof and the Horizontal Dial, to draw the reflected hour-lines on any Cieling or Wall, be it never ſo concave or convex.

To do which: Firſt note, that all ſtraight lines in any projection on any Plain, do always repreſent great Circles in the Sphere, ſuch are all the hour-lines.

Place the center of this Horizontal Dial in the center of the Glaſſe, the hour-lines of the ſaid Dial being horizontal, and the Meridian of the ſaid Dial in the Meridian of the world, which may be done by plumb lines let fall from the meridian on the Cieling: Then fix the end of a thread or ſilk in the ſaid center of the Dial or Glaſſe, and draw it directly over any hour-line on the Dial which you intend to draw, and at the further ſide of the room, and there let one hold or faſten that thread with a ſmall nail.

Then in the point formerly found on the reverſed Axis on the floor, fix another thread there (as formerly was done in the center of the Diall) then take that thread, and make it juſt touch the thread (on the hour-line of the Horizontal Dial extended) in any point thereof, it matters not whereabouts, and mark where the end of that thread toucheth the Wall or Cieling, and there make ſome mark or point.

Then again move the ſame thread higher or lower at pleaſure, till it, as formerly touch the ſaid ſame hour thread, and mark again whereabouts on the wall or Cieling, the end of the ſaid thread alſo toucheth. In like manner may be found more points at pleaſure, but any two will be ſufficient for the projecting or drawing any hour-line on any plain, how irregular ſoever. For if you move a thread, and alſo your eye to and fro, until you bring the ſaid thread directly between your eye and the points formerly found, you may project thereby as many points as you pleaſe at every angle of the Wall or Cieling, whereby the reflected hour-line may be exactly drawn.

Again, in like manner remove the ſaid thread faſtned in the center of the Horizontal Dial, (which alſo is the center of the Glaſſe) on any other hour-line deſired to be drawn, and as before faſten the other end of the thread, by a ſmall nail, or otherwiſe at the further ſide of the room, but ſo that the ſaid thread may lie juſt on the hour-line propoſed to be drawn on the Horizontal Dial. Then (as before) take the thread faſtened in the point on the reflected Axis, and bring it to touch the thread of the hour-line in any part thereof, and mark where the end of that thread toucheth the ſaid Wall or Cieling: Then again (as before) move the ſaid thread ſo, as that it only touch the ſaid thread of the hour-line in any other part thereof, and alſo mark where the end of that thread toucheth the ſaid Wall or Cieling: So is there found two points on the Wall or Cieling, being in the reflected hour-line deſired, by help of which two points the whole hour-line may be drawn; for if (as before) a thread be ſo ſcituated, that it may interpoſe between the eye and the ſaid two points found, you may make many points at pleaſure, whereunto the ſaid thread may alſo interpoſe, which for more conveniency may be made at every angle or bending of the Wall or Cieling, be they never ſo many: So that if lines be drawn from point to point, that ſaid reflected hour-line will be alſo exactly drawn.

In like manner may the other hour-lines be drawn ſo, that the Reflex or ſpot of the Sun from the ſaid Horizontal Glaſſe ſcituated in the ſaid window (as before) ſhining amongſt the ſaid reflected hour-lines drawn on the wall or Cieling, will exactly ſhew the hour of the day deſired.

Now if lines be drawn round about the ſaid Room, equal to the Horizon of the ſaid Glaſſe, it will ſhew when the Sun is in or neer the Horizon.

To draw the Æquator and Tropicks on any Wall or Cieling to any Horizontal reflecting Glaſſe.

1 *To draw the Reflected Æquator or Equinoctial-line on the Wall or Cieling, which repreſents a great Circle.*

TAke the thread fixed in the Center of the Glaſſe, and move the end thereof to and fro in the meridian line drawn on the Cieling, untill by help of a Quadrant the ſaid thread be elevated equal to the complement of the Latitude, (which will be alwayes perpendicular to the reverſed Axis) marking in the me-

Meridian where the end of that thread falls, then on that point and the ſaid meridian line on the Cieling erect a perpendicular line, which line may be continued on any plane whatſoever, and is the reflected Equinoctial line deſired.

Note that all great Circles are right lines, & are alwayes drawn or projected from a right line.

2. *To draw the* Tropicks. *Note, that all Parallels of Declination are leſſer Circles, and are Conick Sections.*

FIrſt, make or take out of ſome Book a Table of the Suns Altitude for each hour of the day, calculated for the place or Latitude propoſed, when the Sun is in either of the Tropicks. Then take the thread fixed in the center of the Glaſſe, and by applying one ſide of a quadrant to the ſaid thread, and moving one end of it to and fro in the hour-line propoſed, elevate the ſaid thread anſwerable to the Suns height in that hour, when he is in that Tropick you deſire to draw, and mark where the end of that thread ſo elevated toucheth in that hour-line propoſed. So may you in like manner finde a ſeveral point in each hour-line for the Suns height in that Tropick, whereby a line may be drawn on the Wall or Cieling from point to point formerly made in the ſaid hour-lines, which the Tropick deſired.

In like manner may any parallel of Declination be drawn: If there be firſt calculated a Table of the Suns altitude at all hours of the day, when the Sun hath any Declination propoſed, whereby may be drawn either the Parallels of the Suns place, or the parallels of the length of the day.

To draw the parallels of Declination to any Reflected Glaſſe moſt eaſily, by help of a Trigon *firſt made on paſt board or other material.*

FIx the Trigon to the reflected reverſed Axis, ſo that the center of the Trigon may be in the center of the Glaſſe, then will the Equinoctial on the Trigon be perpendicular to the ſaid Axis: then take the thread fixed in the center of the Glaſſe, and lay it along either of the Tropicks or other parallels of Declination required, which is drawn on the ſaid Trigon, which thread muſt be continued ſo, that the end thereof may touch any hour-line, and on that hour-line mark the point of touch, the thread being ſtill laid on the ſame parallel of declination on the Trigon: in the ſame manner finde a point in each hour-line. Laſtly, draw a line by thoſe points ſo found, which will be the Tropick-line or other parallel of declination, as the thread was laid on, on the Trigon.

To draw the Azimuth-lines on any Wall or Cieling to any Horizontal reflecting Glaſſe. Note that all Azimuths are great Circles.

FIrſt, find a vertical point, either above to the Zenith, or below to the Nadir of the Glaſſe (by ſome called a perpendicular or plumb line) and mark in what point it cuts the floor of the room, which point I call the reflected vertical point, wherein the end of a thread is to be fixed: For by a point found in the reflected Axis of the Horizon the Azimuths may be drawn, as by a point found in the reflected Axis of the Equinoctial the hour-lines may be drawn.

Then on paſtboard or other material draw the points of the Compaſſe or other degrees, and fix the center thereof in the center of the Glaſſe, and the meridian thereof in the meridian of the world, as was ſhewn in drawing the hour-lines, being careful to place it horizontal.

Then take the thread fixed in the place of the glaſſe, and draw it over any Azimuth, which is deſired to be drawn, and at the further ſide of the Room faſten that thread with a ſmall nail as it was in drawing the reflected hour-lines: Then take the thread whoſe end is faſtened in the ſaid reflect vertical point, and bring that thread ſo as juſt to touch the ſaid horizontal thread, and augment it, until the end thereof touch the wall or Cieling, and there make a mark or point. In like manner, move the ſaid thread, whoſe end is faſtened in the ſaid vertical point, higher or lower at pleaſure, till as formerly it touch the ſaid horizontal thread, and mark again whereabouts the end thereof toucheth the ſaid Wall or Cieling: Now by help of theſe two points found in the reflected Azimuth line, the whole Azimuth line may be drawn; for if (as before in drawing the Hour-lines) a thread be ſo ſcituated, that it may interpoſe between the eye and the ſaid two points, you may make many points at pleaſure, to which the ſaid thread ſo ſituated may alſo interpoſe, which may be made at every angle or bending of the wall or Cieling (as before) whereby the reflected Azimuth-line deſired may be drawn. In like manner may the other reflected Azimuth lines be drawn.

Alſo there may be lines drawn parallel to the Horizon round about the room, by help of the thread fixed in the center of the Glaſſe, and a *Quadrant* for the elevation thereof, which will ſhew the Suns altitude at any appearance thereof.

Thus have I ſhewed the drawing of a Reflected Dial from an Horizontal Glaſſe, with all the uſual furniture thereon, though the wall or place on which it is to be drawn be never ſo gibous or irregular, or in what ſhape ſoever.

Now the Glaſſe may be exactly ſituated Horizontal, if you draw a reflected parallel for the preſent day, and know alſo the true hour, and ſo place the Glaſſe, that the ſpot or reflex of the Sun may fall thereon on the Cieling, for there is no way by an Inſtrument to do it, the Glaſſe is ſo ſmall.

Of

Of Reclining Reflecting Glaſſes.

Reflected Dialling from any Reclining Glaſſe.

I ſhall now ſhew how to draw any Reflected Dial, with all the Furniture (that poſſible may be) the Glaſs being ſet at any poſſible Reclination.

In the drawing of which there is principally to be conſidered,

1 *The Reflected Horizon.*
2 *The Reflected Meridian.*

Note, the Horizon & Meridian are two great circles.

1 *To draw the Reflected Horizon according to the ſituation of any reclining Glaſſe whatſoever.*

Firſt, let two pieces of nealed wire be faſtened on the window on each ſide of the ſaid Glaſſe, the ends thereof being without the room in the air, at whoſe ends let there be faſtned a thread which may be pulled ſtraight at pleaſure, by bending of the wire, then bend thoſe wires upward or downward, until the thread faſtened at the end of each wire be exactly horizontal with the center of the Glaſſe, which may be tried by a quadrant: Then I tie a ſtring or thread croſs the room, in ſuch ſort that I may from moſt part of the thread ſee the reflecting glaſs, and therein the ſaid horizontal thread without the room: Then on the ſaid thread croſs the room, I tie a ſlipping knot to move to and fro at pleaſure, which knot I move to and fro on the ſaid thread, until by looking in the ſaid Glaſſe I finde from my eye the ſaid knot and part of the horizontal thread without, all as it were in a right line, the one interpoſing the ſight of the other.

Then being careful to keep the knot in that poſition, faſten one end of a thread in the place of the center of the reclining reflecting glaſſe, and bring that thread ſo, as juſt to touch the aforeſaid knot, augmenting that thread, until the end thereof touch the wall or Cieling, and there make a mark or point, ſo is there one point found on the Wall or Cieling in the Reflected Horizon of the World. Then I begin again, and remove the poſition of that thread (which went overthwart the Room) either higher or lower at pleaſure, ſtill having regard that I may from the moſt part of the ſaid thread ſee the Reflecting Glaſſe, and therein the ſame horizontal thread without the room. Then, as before, I move the ſaid knot on the ſaid thread to & fro, until (as before) by looking in the ſaid Glaſſe I find from my eye the ſaid knot, and part of the Horizontal thread both in one right line, the one interpoſing the ſight of the other; and by the ſaid knot I bring that thread, whoſe end is faſtened in the center of the ſaid glaſſe, and keeping it juſt to touch the ſaid knot, I continue it, until the end thereof touch the Wall or Cieling, as before, and there I make another mark or point; ſo is there two points found in the ſaid reflected Horizon on the wall or Cieling. By which ſaid two points, if a thread (as before) be ſo ſcituated, that it may interpoſe between the eye and the ſaid two points, there may be many points made to be in the ſame interpoſition of the thread, which (as before) may be made at every bending or angle of the Wall or Cieling, whereby the reflected Horizon deſired may be drawn, by drawing a line from point to point round about the Room; Which wil be the true reflected Horizon according to the ſituation of the glaſſe.

2 *To draw the Reflected Meridian, according to the ſituation of any Reclining Glaſſe whatſoever.*

FIrſt, take a lath or thin piece of wood of any convenient length at pleaſure, as ſome one and an half, or two foot long, and at each end thereof make a hole, the one to hang a thread and plummet, and the other is to put a ſmall nail therin to faſten it in ſome part of the window over the center of the Glaſſe, ſo that the thread and plummet may hang without the room: then by help of the Suns Azimuth you may draw the meridian line, (as before) as if the Glaſſe were horizontal, and move the lath with the thread and plummet at the end of it to and fro, until the thread and plummet be in the direct meridian of the world with the center of the Glaſſe. Then (as before) tie a thread croſſe the room, in ſuch ſort that from or by ſome part of the ſaid thread both the Reclining glaſſe and the thread to which the plummet is faſtened may be ſeen at one time. Then (as before) on the ſaid thread, which croſſes the room, I tie a ſlipping knot, which I move to and fro on the ſaid ſtring, until by looking in the ſaid Glaſſe I find from my eye the ſaid knot and ſome part of the perpendicular thread without, all as it were in one right line, the one ſhadowing or interpoſing the ſight of the other, being then very careful to keep that knot in the ſame poſition, then take the thread (whoſe end whereof being faſtened in the ſaid center of the Glaſſe) and bringing it juſt to touch the ſaid knot, I augment that thread, until the end thereof touch the ſaid wall or Cieling, and the ſaid thread alſo touch the knot, as before: then in that place where the end of the ſaid thread toucheth the wall or Cieling, I make a mark, which mark or point will be directly in the reflected meridian of the world, according to the ſituation of that Glaſſe. Then again I remove that thread (overthwart the room) on which the ſaid knot is, either higher or lower then it formerly was at pleaſure, ſtill having regard that from ſome part of the ſaid thread within, you may ſee both the Reclining Glaſſe, and the perpendicular thread without at one time; and (as before) move the ſaid ſlipping knot on the ſaid thread, until by looking in the ſaid Reclining Glaſſe, you ſee the ſaid knot and ſome part of the perpendicular thread without in one right line, ſo as the one ſhadows or hinders the ſight of the other, (as before) which knot then muſt not be removed from its ſituation, then take that thread (whoſe end is faſtened in the Glaſſe) and bring it to touch that knot, the end of the ſaid thread being continued to touch the wall or Cieling: ſo is that point of touch on the Cieling another point found in the Reflected Meridian of the world. So is there two points found in the ſaid Reflected Meridian, on the wall or Cieling; by which, if a thread (as before) be ſo ſituated, that it may interpoſe between the eye and the ſaid two points, many points thereby in the ſaid reflected Meridian may be made at every bending or angle of the wall or Cieling, whereby the Reflected meridian deſired may be drawn, by drawing a line from point to point obliquely in the Room, which will be the true Reflected Meridian of the world, according to the ſituation of that Glaſſe.

Now this Reflected Horizon and Meridian being firſt drawn, they will be of great uſe in drawing the Hour-lines, together with all the furniture that poſſibly can be drawn on any Diall.

To draw the Reflected Hour-lines to any Reclining Glaſſe on any plane whatſoever, that the Sun will be reflected on: By help of an ordinary Horizontal Dial for that Latitude.

First, extend ſeveral threads from the center of the Glaſſe to the extremity of the Reflected Horizon in the Room (which for more conveniency and uſe may be the ſeveral hour-lines, and may alſo ſerve as a bed to ſituate the Horizontal Diall on the Reflected Horizon) having regard to ſituate the center of the Dial on the center of the Glaſſe, and the Meridian of that Dial on the Reflected Meridian of the World: Then to finde the point in the Reflected reverſed Axis on the floor of the Room; Take a thread, one end thereof being faſtened in the center of the Glaſſe, and move the other end thereof to and fro in the reflected meridian under the Reflected Horizon, until by help of a Quadrant the ſaid thread is found to be depreſſed under the reflected Horizon, equal to the latitude of the place, and where the end of the ſaid thread interſects or meets the Reflected Meridian either on the floor or wall, that point is the reflected reverſed Axis, as was required. In which point faſten one end of a thread, which thread will be of great uſe in drawing the reflected hour-lines on any wall or Cieling whatſoever. Now if this thread, whoſe end is faſtened in a point on the reflected reverſed Axis, be taken and brought to touch any part of any one of the threads of the hour-lines (produced to and faſtened in the reflected Horizon) the ſaid thread being continued ſo, as the end thereof may touch the wall or Cieling, and alſo any part of the ſaid thread touch the hour-line or thread propoſed; that point on the wall or Cieling is in the reflected hour-line deſired to be drawn: Alſo the other point in the ſame reflected hour-line may be found; If the ſaid thread, whoſe end is faſtened in the Reflected Axis, be brought to touch ſome other part of the ſame hour-thread propoſed; ſo that when (as before) the end of the ſaid thread toucheth the wall or Cieling, ſome part of that thread may alſo touch the hour-line deſired, which point of touch on the wall or Cieling, is alſo another point in the ſaid reflected hour-line deſired. By which two points ſo found (as before) the reflected hour-line may be drawn by a thread, projecting by thoſe points from the eye, as it was formerly directed in drawing the reflected hour-lines to an Horizontal Glaſſe.

To draw the Reflected Equinoctial line, and alſo the Tropicks on any wall or Cieling, to any Reclining Reflecting glaſſe.

1 *To draw the reflected Equinoctial line on the Wallor Cieling.*

TAke that thread, whoſe end is faſtened in the center of the reclining glaſſe, and move the other end thereof to and fro in the ſaid Reflected meridian formerly drawn, until (by help of a quadrant) the ſaid thread is elevated above the reflected Horizon formerly drawn, equal to the Complement of the Latitude, (which as before will be alwayes perpendicular to the reverſed Axis) and make a point in the ſaid reflected meridian, where the end of the ſaid thread toucheth; then on that point and the ſaid reflected meridian on the Cieling, raiſe a perpendicular line, which is the Reflected Equinoctial line deſired.

2. *To draw the reflected* Tropicks, *or other Parallels of Declination.*

FIrſt, (as before) make or take out of ſome Book a Table of the Suns Altitude for each hour of the day, calculated for the place or Latitude propoſed, when the Sun is in either of the Tropicks, or other parallel of Declination: then take that thread, whoſe end is faſtened in the center of the Glaſſe, move the other end thereof to and fro in the hour-line propoſed, until by applying one ſide of a quadrant to the ſaid thread you find the ſaid thread elevated above the reflected Horizon anſwerable to the Suns height in that hour propoſed, when he is in that Tropick or degree of Declination propoſed. Which altitude required will be found in the foreſaid Table for that end calculated, which ſaid thread being of the elevation above the reflected Horizon, as the ſaid Table directeth: then mark where the end of the thread (ſo elevated) toucheth the Wall or Cieling in that hour-line: ſo is one point found in the reflected parallel of Declination deſired to be drawn. In like manner, find in the ſaid Table in the ſame parallel or degree of declination what altitude the Sun hath at the next hour, and elevate the ſaid thread, whoſe end is faſtened in the center of the Glaſſe, equal to the Suns altitude in that hour above the ſaid reflected Horizon, by help of the ſaid Quadrant, and where the other end of the ſaid thread falleth in the hour-line propoſed, make another mark or point. And ſo in like manner make the points (belonging to that parallel of Declination) in the remaining hour-lines, according to the ſeveral Altitudes found in the ſaid Table of Altitudes: Then drawing by hand a line to paſſe through thoſe ſeveral points ſo found, as before, which line is the reflected parallel of the Suns declination deſired. In like manner may be drawn all or any other parallel of Declination, which may have reſpect to the Suns place, or the length of the day, as ſhall be deſired.

Or,

To draw the ſaid reflected Tropicks, or other parallels of Declination, without any Tables calculated, only, by help of a Trigon *firſt made on paſtboard or other material.*

Note that all Parallels are leſſer Circles.

First (as formerly is ſhewd in drawing the parallels of Delination to a Reflecting Horizontal Glaſſe) faſten the Trigon on the reflected reverſed Axis, ſo that the center of the Trigon may be in the center of the Glaſſe, then alſo will the Equinoctial on the Trigon be perpendicular to the ſaid reflected reverſed **Axis** : then take the thread fixed in the center of the ſaid Glaſſe, (which is alſo in the center of the Trigon) and lay it upon that parallel of Declination, drawn on the ſaid Trigon, whoſe reflected parallel is required to be drawn on the plane or Cieling: then move the Trigon, the thread lying on the ſaid parallel, until the end of the ſaid thread touch any hour-line on the ſaid wall or Cieling, in which point of touch on that hour-line make a mark, ſo will that point be in the reflected parallel of Declination deſired. In like manner, move the ſaid Trigon, ſtill keeping the thread on the ſame parallel, until the end of that thread touch another hour-line on the ſaid plane or Cieling, and there alſo make another mark. And ſo in like manner find a point in each hour-line through which that reflected parallel muſt paſſe ; then drawing a line to paſſe through thoſe ſeveral points on the ſaid plane or Cieling, which line is the reflected parallel of the Suns Declination deſired.

In like manner may be drawn any other reflected parallel of Declination required.

To draw the reflected Azimuth-lines to any reclining Glaſſe, on any plane whatſoever that the Sun-beams will be reflected on. Here note that Azimuths are great Circles.

FIrſt, know that the reflected vertical point in the Axis of the Reflected Horizon, will alwayes be found in the reflected meridian. And look how many degrees the reflected Horizon differs from the direct Horizon, ſo many muſt the reflected Axis of the Horizon differ from the direct Axis of the Horizon: Hence the reflected vertical point, whereby the reflected Azimuth-lines are drawn, may be thus found.

Take that thread whoſe end is fixed in the center of the Glaſſe, and move the other end thereof to& fro in the reflected meridian, until by applying one ſide of a quadrant thereto, you find the ſaid thread depreſſed juſt 90 degrees, or perpendicular under the reflected Horizon; then make a mark or point where the other end of the ſaid thread toucheth the ſaid reflected Meridian on the Wall, Ground, or Floor of the Room, which point ſo found is the reflected vertical point deſired, in which point faſten one end of a thread:

Then on paſtboard or other material draw the points of the Compaſſe or other degrees, placing the center thereof in the center of the Glaſſe, and the meridian thereof in the reflected meridian of the world, which ſaid paſtboard muſt be alſo ſituated in the reflected Horizon juſt as the Horizontal Dial was formerly directed to be ſituated for drawing the reflected hour-lines: And as the threads from the center faſtened in the reflected Horizon were alſo the hour-lines on the Horizontal Diall, whereby the reflected hour-lines were drawn. So now the threads from the center faſtened in the Reflected Horizon may be the Horizontal Azimuth lines, whereby the reflected Azimuth-lines may be drawn: Or if that thread which faſtned in the center of the glaſs be drawn exactly over any Azimuth-line, the end whereof being faſtened by a nail or other means in the reflected Horizon on the other ſide of the Room, there may ſeveral points be found in the wall or Cieling, through which the reflected Azimuth line muſt paſſe, as followeth :

Take that thread, one end of which is faſtened in the ſaid vertical point, and bring it juſt to touch the Azimuth thread formerly faſtened, and continue it until the end thereof touch the wall or Cieling, (and alſo the thread it ſelf touch the ſaid Azimuth it ſelf, as before) in which point of touch on the wall or Cieling make a mark, through which point that reflected Azimuth-line muſt paſſe. Then move the ſaid ſtring faſtened in the ſaid vertical point, ſo that it may juſt touch the ſaid thread again, but in another place: then as before continue that thread, untill the end thereof touch the wall or Cieling again, as before, and there make another mark, through which the ſaid reflected Azimuth line muſt alſo paſſe; In like manner may more points be found for your further guide, in drawing that Azimuth-line. But two points being found will be ſufficient.

To draw any reflected line by any two points given over any plane whatſoever, without projecting by the eye.

FAſten two threads in the place of the center of the ſaid reclining Glaſſe, drawing the ſaid threads ſtraight, faſtening each of the other ends in the two reflected Azimuth-points formerly found on the wall or Cieling. Then ſituate a thread croſs or thwart the room, ſo as it may croſſe thoſe other threads from the center, neer at right angles, and alſo juſt touch both of them in that ſituation. By which ſaid thread croſſe the room may any number of points in the ſaid reflected Azimuth-line to be drawn, be found at pleaſure : For if the end of another thread be alſo faſtened in the center of the ſaid Glaſſe, making the other end thereof to touch the wall or Cieling, but ſo that it may alſo juſt touch the ſaid thread, which is faſtened croſſe the room, which point of touch on the ſaid wall or Cieling is another point in the ſaid reflected Azimuth line required to be drawn. In like manner may more points be found at every angle or bending of the wall or Cieling for the exacter drawing the reflected Azimuth line required, which doth find points, whereby is drawn the ſame reflected Azimuth line (or other lines) as was formerly done by a thread ſo ſituated, that it may interpoſe between the eye and any two points aſſigned on the wall or Cieling.

In like manner, if the thread faſtened on the further ſide of the room were removed on another Azimuth line on the ſaid paſtboard, and then faſten it again on the further ſide of the room (as before) you may by help of the ſaid thread faſtened in the ſaid vertical point find ſeveral points on the wall or Cieling, through which that Azimuth-line will paſſe; So may you either by this or the former way draw what Azimuth lines you pleaſe, either in points of the Mariners Compaſſe or degrees, as you pleaſe, by drawing it firſt on paſtboard, as before is directed.

And note generally, that ſuch relation the point found on the floor or ground in the reflected reverſed Axis, hath to the hour-lines drawn on the Horizontal Dial, in drawing the reflected hour-lines; The ſame hath the Reflected vertical point found on the floor or ground, to the Azimuths drawn on the paſtboard in drawing the reflected Azimuth-lines.

To draw the reflected parallels of the Suns altitude, or proportions of ſhadows to any reclining Glaſſe on any Plane whatſoever, that the Sun-beams will be reflected on.

Here note, that parallels of Altitude are leſſer Circles, therefore are not repreſented by a right line.

First, know generally that what reſpect the parallels of Declination have to the hour-lines, ſuch have the parallels of Altitude to the Azimuths.

For if one end of a thread be faſtened in the place of the center of the reclining Glaſſe, and the other end moved to and fro in any reflected Azimuth line, until the ſaid thread be elevated any number of degrees propoſed above the reflected Horizon (the Elevation of which thread being found, by applying a Quadrant thereto, and making a mark or point where the end of the ſaid thread toucheth the ſaid reflected Azimuth drawn on the wall or Cieling, that point ſo found is the point through which that Almicanter or reflected parallel of the Suns altitude muſt paſſe.

In like manner, remove the other end of the ſaid thread faſtned in the center of the Glaſſe to another reflected Azimuth-line, and (as before) move it higher or lower, untill by applying the edge of a quadrant to that thread, you find the ſaid thread above the reflected Horizon the ſame number of degrees firſt propoſed, and at the end of the ſaid thread in that Reflected Azimuth-line drawn on the wall or Cieling I make another mark or point, through which the ſame Reflected Almicanter or parallel of Altitude muſt alſo paſſe: And ſo in like manner I find a point on each reflected Azimuth-line, through which the ſame parallel of Altitude muſt paſſe. Then drawing by hand a line to paſſe through theſe ſeveral points ſo found, as before, that line is the Reflected parallel of the Suns Altitude propoſed. In like manner may be drawn all the other parallels of Altitude deſired, which will ſhew the Suns altitude or the Proportion of any ſhadow to its altitude, at any appearance of the Suns reflex thereon.

To draw the Jewiſh or old unequal hour-lines to any Reclining Glaſſe on any plane whatſoever that the Sun-beams will be reflected on. Here note that the Jewiſh hour-lines are great Circles.

First, (by the Rules formerly given) draw two reflected parallels of Declination of 16*d.* 55′, the one being neer the Summer, and the other neer the Winter-Tropick: for when the Sun hath that Declination, the day is 15 hours long in the Summer, and 9 in the winter: Then (as is formerly directed) ſituate a thread juſt between the eye, and thoſe three points in the ſaid Reflected Dial, as is expreſſed in the inſuing Table, ſo may you thereby draw all or any of thoſe Jewiſh hour-lines deſired, which will at any appearance of the ſpot by the reflex of the Glaſſe amongſt thoſe hour-lines, ſhew how many of the equal hours is paſt ſince Sun-riſing, as was deſired. Now in this Latitude of 51 deg. 30′, If the parallels of the Suns declination be drawn, both when the day is 9 and 15 hours long, that is, when it is 16*d.* 55′, any of thoſe Jewiſh hour-lines will interſect the common hour-lines, either upon the hours, half hours, or quarters. And ſuch a declination may be found, that it ſhall ſo do in any Latitude deſired.

Unequal Hours.	15 H. M.	*Equ.* H.	9 H.M.	*Unequ. hours*	15 H. M.	*Equ.* H.	9 H.M.
0	4 30	6	7 30				
1	5 45	7	8 15	7	1 15	1	0 45
2	7 00	8	9 00	8	2 30	2	1 30
3	8 15	9	9 45	9	3 45	3	2 15
4	9 30	10	10 30	10	5 00	4	3 00
5	10 45	11	11 15	11	6 15	5	3 45
6	12 00	12	12 00	12	7 30	6	4 30

To draw the Circles of Poſition to any reclining Glaſſe on any plane whatſoever, that the Sun-beams will be reflected on.

NOte that all Circles of Poſition are great Circles of the Sphere, and do alwayes interſect each other in that point of the Reflected meridian which toucheth the Reflected Horizon, which may be called the common interſection; which ſaid Circles of Poſition are reckoned upon the Reflected Equinoctial both wayes from the ſaid meridian down to the ſaid Horizon: The Horizon Eaſtward being the Cuſpis of the firſt Houſe, and the Horizon Weſtward being the Cuſpis of the ſeventh Houſe; and the Reflected meridian the cuſpis of the tenth Houſe. So that thoſe Meridian-planes, whoſe Reclination is 60 degrees Weſtwards, (being meaſured from the meridian in the Equinoctial) lies in the Cuſpis of the eighth Houſe, and 30 degr. Weſtward lies in the Cuſpis of the ninth houſe, and 30 deg. Eaſtward in the Cuſpis of the eleventh Houſe, and 60 deg. Eaſtward in the Cuſpis of the twelfth Houſe: which are all the Houſes above the Horizon.

Now to draw any Circle of Poſition, or the Cuſpis of any Houſe on any Cieling or wall to any reclining Glaſſe is done as followeth:

Firſt, faſten a thread, in ſuch ſort, within the Room, as that it may interpoſe between the eye and the ſaid common point of interſection on the wall or Cieling, and alſo between that point where the reflected hour-line of 4 (being 60 deg. Weſtward from the ſaid Meridian) interſects the reflected Equinoctial alſo on the Cieling, whereby points may be made at every bending or angle of the wall or Cieling, to which the thread ſo ſituated may alſo interpoſe, by which points the Reflected Cuſpis of the eighth Houſe may be drawn. In like manner may the Cuſpis of any other Houſe above the Horizon, as the *9th.* or *10th.* which is the Meridian (or *Medium Cœli*) or *11th.* or *12th.* be drawn alſo. For if (as before) the ſaid thread be again ſo faſtened within the Room, as that it may alſo interpoſe between the eye and the ſaid common point of interſection, and alſo thoſe points where the reflected hour-line of 2 (being 30 deg. Weſtward from the ſaid meridian) do cut the reflected Equinoctial, whereby may be drawn the reflected Cuſpis of the ninth Houſe. Or where the Reflected hour-line of 10 (being alſo 30 deg. Eaſtward from the meridian) do alſo cut the ſaid reflected Equinoctial, whereby may be drawn the Cuſpis of the *11th.* Houſe. Or where the reflected hour-line of 8 (being 60 deg. Eaſtward from the meridian) do alſo cut the ſaid reflected Equinoctial, whereby may be drawn the Cuſpis of the *12th.* Houſe. The Horizon alwayes being the Cuſpis of the firſt and ſeventh Houſes, and the meridian the Cuſpis of the tenth houſe or *Medium Cœli:* wherein generally it is to be noted, That in all planes which cut the common Interſection of the meridian and Horizon, (as doth the Horizontal, and alſo all meridian planes both Direct and Reclining) theſe Circles of Poſition are all parallel to the meridian, and therefore parallel each to other. For look what reſpect the hour-lines in all Direct or Reclining Polar Planes, or Direct meridian Planes have to the Axis of the World: Such reſpect have the Circles of Poſition, in all Horizontal, or Direct meridian or Reclining meridian Planes, to the Axis of the Prime vertical: For as the hour-lines in the firſt are all parallel to the Axis of the Equinoctial, in whoſe Poles they meet: So the Circles of Poſition in the ſecond are all parallel to the Axis of the Prime Vertical, in whoſe Poles they alſo meet.

The reaſon why Glaſſes reflect a double Spot, is becauſe they are poliſht on both ſides, which may be remedied with a Pumex-*ſtone. Thoſe that deſire to read more of this Subject may ſee what is written by* Kircher, in primitiis Gnomicæ Catoptricæ, *and ſince him by* Magnan *and others,*

VALE.

FINIS.